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# ADHD Children's Emotion Regulation in FACE© – Perspective (Facilitating Adjustment of Cognition and Emotion): Theory, Research and Practice

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Additional information is available at the end of the chapter

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## 1. Introduction

Children with ADHD are known to display primary features of impulsivity, inattention and/or hyperactivity [1]. They also constitute a diverse group, encompassing predominantly inattentive (ADHD-I), hyperactive/impulsive (ADHD-HI) and combined (ADHD-C) subtypes with multiple comorbidities and developmental paths [2]. ADHD children's cognitive functioning and outcomes have been investigated extensively. Remarkably, much less research and prevention efforts have been devoted to their emotional processes and outcomes [2-4]. Consistent with a surge in research placing emotions at the centre of various psychopathologies over the past decade, a start has been made toward gaining a more balanced view of ADHD children's functioning.

This chapter discusses why emotion research is important for ADHD children (§2), presents the FACE®-model (Facilitating the Adjustment of Cognition and Emotion, [5, 6]) (§3) as a comprehensive framework through which to identify the major components and levels of emotional and associated cognitive functioning covered by the broad concept of emotion regulation (ER) (§4) and critically reviews which of these issues have been investigated in the context of ADHD (§5). The chapter pursues with identifying cautions and conditions for translating research into practice and reformulating these into a resiliency perspective on ADHD children's emotional functioning, after which implications are drawn from the evidence-base to inform intervention and prevention efforts with ADHD youth and their families (§6). The chapter briefly rounds out by outlining a strengths-based perspective on further emotion-oriented research and practice with ADHD youth (§7).

## 2. Why emotional functioning matters in children with ADHD

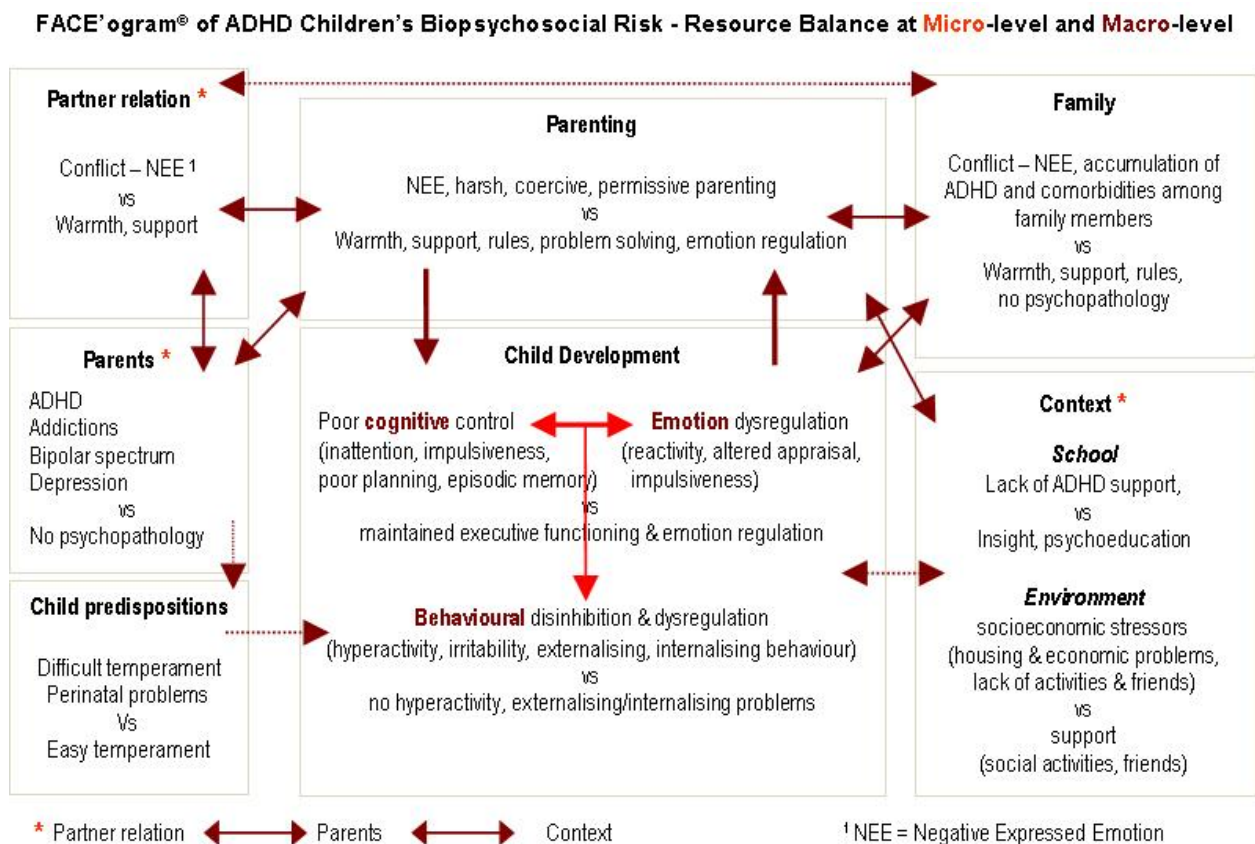
ADHD children's frequent learning and academic difficulties have received ample attention [1,2]. Programs destined at helping children with ADHD typically focus on alleviating the behavioural components that contribute to such difficulties in order to facilitate their school and subsequent professional curriculum. Less extensively investigated yet widely documented is ADHD children's often complicated social, relational and family functioning [7-9]. Children with ADHD are known, for example, to have more negative peer relationships [10], be subject to bullying [11], engage in risk-taking and antisocial behaviour [12], and experience family difficulties [4, 13, 14]. While these risk factors have led to underscoring the importance of social skills training for children with ADHD, relatively few studies to date have investigated these issues from an emotion perspective that may shed light on their underlying mechanisms.

Children with ADHD are also diagnosed more often than not with comorbid disorders [1], such as conduct disorder (CD) and oppositional defiant disorder (ODD) in 40 to 60% of cases [15-17], as well as anxiety and depression (including suicide risks) [17-20]. Attachment problems [21, 22] and posttraumatic stress symptoms/disorder are also frequently associated with ADHD [12, 23]. Furthermore, Bipolar Disorder (BD) constitutes a major possible comorbidity with emotional implications for ADHD children [5, 24-26]. Pointing to yet another line of potential deficits in emotion processing, it is also increasingly acknowledged that children may concurrently present with ADHD and autism spectrum symptoms or disorder (ASS/D) [27-29].

When evaluating the impact of ADHD on children's developmental course, research therefore typically grapples with the issue of disentangling to what extent their relational and social problems are a mere consequence of their core behaviour regulation difficulties, or whether and when these problems reflect more fundamental facets of their emotional functioning. In addition, the pervasiveness of emotion-related difficulties throughout the spectrum of ADHD subtypes and comorbidities questions the extent to which such difficulties are ADHD (subtype) specific or represent overarching mechanisms of emotional dysregulation that broadly put children at risk for experiencing clinical problem behaviour.

## 3. ADHD children's behaviour in FACE®-perspective: Cognitive and emotional adjustments within a risk-resiliency context

While diverse areas of research address the above-cited issues separately, there is a need to move toward a comprehensive, integrated view of ADHD children's cognitive and emotional functioning, so as to inform research as well as prevention and intervention efforts in this context. Stated in a nutshell and schematized in Figure 1, the FACE®-model aims to respond to this need by focusing on ADHD children's reciprocal adjustments of cognitive control and emotion regulation on a micro-level, while accounting for biopsychosocial risk and resiliency dynamics on a macro-level [4-6].



**Figure 1.** ADHD Children's Functioning in FACE©-perspective, at Cognitive-Emotional Micro-level and at Biopsychosocial Macro-level

The FACE©-model thus posits that in order to constructively apprehend and act upon ADHD children's behavioural and relational challenges, it is necessary to gain insight into their cognitive-emotional adjustment processes within the ecological context of their experienced allostatic load [30]. Importantly, systematically accounting for the risk and resiliency balance operating in the ADHD child's life should also contribute to a strengths-based approach that fosters the 'positive faces' of ADHD and thereby pave the way for effective prevention and intervention programs [4, 31, 32]. Figure 1 illustrates this model at micro-level [6, 25, 33-35] and at macro-level [4, 6, 30], as discussed hereafter.

### 3.1. The role of reciprocal cognitive and emotional adjustments on a micro-level

The notion that successful coordination of cognitive control and emotion regulation is pivotal to adaptive behaviour has been increasingly recognised over the past decade.

From a predominantly *cognitive* perspective, ADHD's cardinal characteristics of impaired sustained attention and impulsiveness provide grounds per se for expecting so-called top-down disturbances of emotional functioning. Attentional fluctuations for example may interfere with how and when the child notices emotional cues, both internal and interpersonal [36-39]. Similarly, poor behavioural control and planning typical of ADHD are likely to hamper, amongst others, the child's ability to postpone emotional responses or to adequately modulate their form and intensity [40-43]. High-order cognitive processes such as behavioural inhibition, sustained attention, attention allocation and cognitive switching indeed are critical to flexibly responding to emotional interactions in everyday life. Neuroscience studies have allowed to quite consistently link ADHD children's problems with these processes to distinct underactivation of inferior frontal cortex (IFC) and dorsolateral prefrontal cortex (DLPFC) circuitries. In comparison, evidence suggests that conduct disordered children display underactivation of paralimbic system areas and bipolar children of ventral frontostriatal circuitry [44, 45].

Even within this top-down perspective, the reciprocal directions of cognitive and emotional effects in behavioural (dis)adjustments need to be underscored. For example, in a five-year follow-up of preadolescent girls with ADHD, the association between childhood executive functioning skills such as planning and adolescent internalising and externalising comorbidity was partially mediated by social functioning in adolescence, and vice versa [46]. Studies in this vein yet still focus on behavioural manifestations of interpersonal functioning rather than on underlying emotional processes. Moreover, although the above predominant 'cognitive-toward-emotional' pathways have been only partially investigated to date, it has become apparent that they do not suffice to fully explain the range of emotional dysfunction and comorbidity in children with ADHD [47, 48].

More recently, ADHD theories have therefore turned to including an *emotion-centred* perspective. This perspective is supported by brain functioning studies on how underlying emotional mechanisms may be disrupted in their own right in the context of ADHD [47, 49]. Neuroimaging studies indeed demonstrate the complexity of the neurobiological circuitry of emotion regulation, which requires continuous adjustments and integration of limbic and prefrontal brain systems [19, 45, 50, 51]. The dorsolateral, orbitofrontal and anterior cingulate cortex in fact are part of complex interrelated networks that mediate emotional and cognitive information processing in relation with striatal, cerebellar, and parietal regions along with the amygdala and hippocampus [44, 45, 48, 51, 52]. More specifically, ADHD disruptions in IFC and DLPFC regions are found to be associated with prominent structural deficits in basal ganglia, deficient connectivity with reduced amygdala along with (possibly compensatory) enlarged hippocampus, all of which mediate emotion processing [44, 49]. Expectations of central emotional disruptions in ADHD children's functioning hereby are further supported by the convergence of certain early-onset ADHD manifestations and the developmental precedence of the emotional brain systems compared to a comparatively late maturing cognitive circuitry [37, 44].

*In short*, from a micro-level perspective, children with ADHD may be vulnerable to emotion dysregulation through predominant 'cognitive-toward-emotional' pathways as well as



through primary disturbances in an intrinsically integrated 'emotional-with-cognitive components' circuitry. This intricacy of reciprocal emotion and cognitive processing provides a basis for neural understanding of the different emotion regulation levels detailed further on.

### 3.2. The role of the biopsychosocial risk and resiliency balance on a macro-level

Several fields of study, such as developmental psychopathology, trauma and stress-related as well as neurobiological investigations, converge to demonstrate that children's dysfunctional behaviour, cognition and emotion do not occur in isolation but relative to an immediate and larger environment [7, 31, 53]. Children's direct and long-term outcomes are determined by a dynamic balance of risks versus resources across several domains throughout their development, as illustrated in Figure 1 [6].

Children with ADHD are known to be at increased risk of confronting additional stressors that even further diminish their perceived resources, notably as regards their parents' (e.g. ADHD, substance abuse, stress, anxiety) and siblings' functioning (e.g. ADHD or behavioural problems) [13, 54, 55], along with the quality of their parenting (e.g. harsh or inconsistent) [56, 57] and family environments (e.g. high levels of negative expressed emotions) [14, 58, 59] as well as school or leisure context (e.g. peer rejection) [10, 11, 60]. In other words, assessing ADHD children's emotional functioning without considering the scope of stressors versus resources operating in their immediate and larger environment will generate only a limited understanding of the processes at hand.

Investigating this risk-resiliency load furthermore may be particularly pertinent to understanding ADHD children's emotional functioning given their peculiar arousal balance. Children with ADHD are indeed documented to struggle simultaneously with being overburdened and under-challenged when processing information [2]. While these features have been demonstrated in predominantly cognitive situations, and while clinical accounts do tend to reflect issues with emotional overburdening in ADHD children's day-to-day interpersonal functioning [4, 61, 62], there is a need for empirical evidence to this regard.

*In short*, ADHD children's emotion regulation skills may be extra challenged given the potential level of additional stressors that they tend to face. Their emotional functioning therefore deserves to be examined against the broader backdrop of cumulative *risks* operating in their lives. Inversely, assessing the impact of contextual *resources* on ADHD children's emotion regulation skills is likely to provide precious leads for enhancing intervention and prevention efforts.

Taking into account these conceptual foundations, the FACE©-model hereafter first more specifically guides our focus on the emotional and associated cognitive components implied in the emotion regulation process (§4). The evidence-base with regard to how these components present in children with ADHD is then primarily discussed on a micro-level (§5, 5.1-5.3). Macro-level parenting and family influences on ADHD children's emotional functioning are briefly reviewed in relation to their cognitive-emotional adjustments (§5.4).

## 4. Which aspects of emotion regulation merit investigation in ADHD children and why?

The field of emotion regulation research is unwieldy and potentially confusing as illustrated hereafter (§4.1). To clarify the evidence-base regarding ADHD children's emotion regulation, the next paragraphs first disentangle its major operational components (§4.2) and then integrate these in the micro-level of the model introduced with Figure 1 (§4.3).

### 4.1. Investigating ADHD children's emotion regulation: A complex issue

The adequate recognition and expression of emotions is fundamental to a child's development, and emotion regulation is instrumental to the personal and relational as well as the cognitive fulfilment of the child [42, 63]. Despite this knowledge, few empirical studies among children with ADHD (or adults for that matter) are specifically dedicated to their emotion regulation skills. It has not helped that emotion regulation tends to be approached in a broad variety of ways, regardless of the investigated population. The focus of ER research with ADHD children notably ranges from physiological mechanisms and neurobiological circuits to questionnaire-based and observational behavioural measures; and from laboratory to ecologically pertinent studies. Furthermore, emotional functioning consists of autonomic, automated and implicit responses [16, 48, 50] as well as deliberate, effortful regulation [20, 37], which adds to the investigation range [42]. In fact, the transient, elusive and subjective nature of emotions has complicated the process of generating an encompassing and yet precise definition of emotion since centuries, and has probably contributed to empirical research shying away from the subject [51, 64]. The conceptualisation history of ADHD thus has moved away during the second half of the 20<sup>th</sup> century from emotional features that were previously included in its core descriptions, only to return to addressing their pervasiveness in the contemporary literature [47]. In recent years, a more pragmatic approach involves focussing on the typical or core features of ER that allow setting a framework with working definitions to guide emotion research [63].

### 4.2. Major operational components and levels of emotion regulation

Three operational specifications of emotion regulation appear particularly pertinent to the present purpose of clarifying the investigation of emotional processes in children with ADHD.

First, *emotions* are bio-psycho-social phenomena that consist of (unconscious, autonomic) physiological reactions, which are accompanied by subjective experiences and behavioural expressions within a given context [48, 63, 65]. Emotion research with ADHD children therefore deserves to include at least three levels of interest, namely a biological, an (introspective) experiential and a behavioural-interpersonal level.

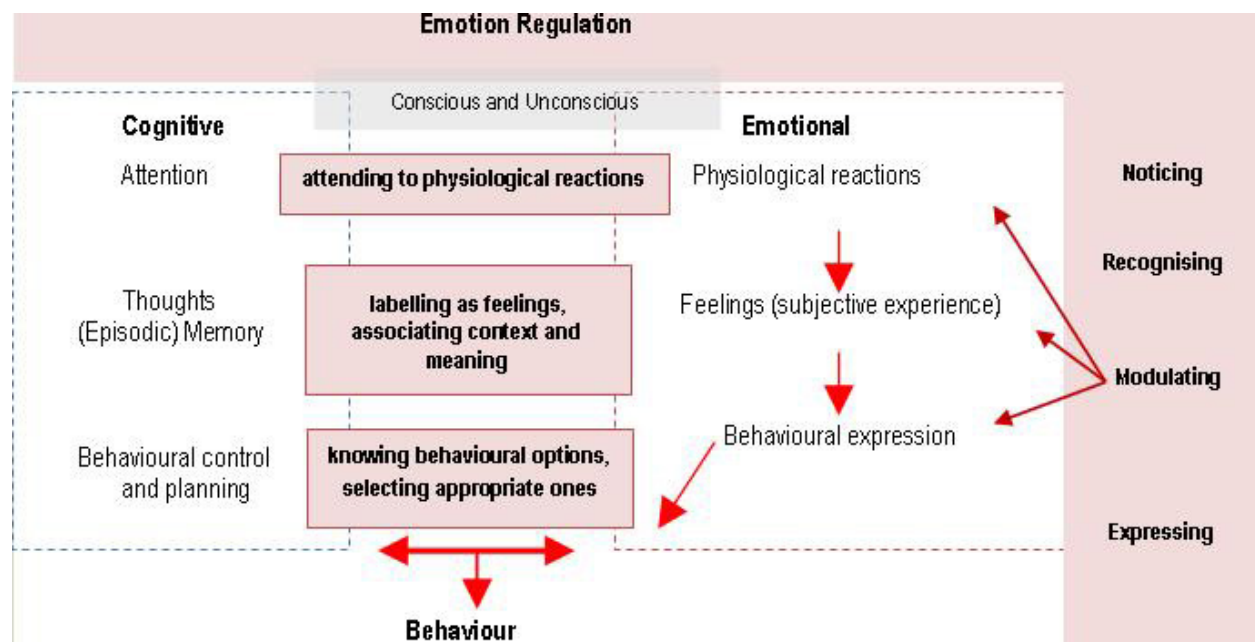
Second, competent *emotional functioning*, which appears to be challenged in children with ADHD, consequently comprises at least three core, interconnected components that merit examination, namely the adequate appraisal, modulation and expression of emotions [42,

50, 63, 64, 66]. Cognitive and emotional processes are intricately interwoven in these components. This is the case, for instance, as thoughts and feelings jointly constitute the subjective experience accompanying a child's initial physiological reactions (appraisal); or as memory intervenes along with emotional reactivity in how the child regulates emotional intensity (modulation); or as attention allocation, planning and attributed feeling reciprocally determine the behaviour through which the child exhibits an emotion (expression).

Third and in line with the above, a more detailed working definition of the *process of emotion regulation* has been proposed by Eisenberg and Spinrad (2004) as consisting of "initiating, avoiding, inhibiting, maintaining, or modulating the occurrence, form, intensity, or duration of internal feeling states, emotion-related physiological, attentional processes, motivational states, and/or the behavioural concomitants of emotion in the service of accomplishing affect-related biological or social adaptation or achieving individual goals" [67, p.338]. This definition further highlights the important range of processes at work in emotion regulation. Taking into account this working definition, ADHD children's important levels of externalising (CD, ODD, BD) as well as internalising comorbidity (anxiety, depression, BD) imply that their emotional arousal, appraisal and expression might carry both 'hot' and 'cold', as well as 'approach' and 'avoidance' features as detailed further on [60].

#### 4.3. ADHD children's emotion regulation conceptually revisited

Closing in on the micro-level of the FACE©-model allows summarising the aforementioned multiple facets and levels of emotional, and associated cognitive, functioning covered by the concept of emotion regulation, as visualised in figure 2.



**Figure 2.** ADHD children's cognitive, emotional and behavioural ER components



Given this broadness of the emotion regulation concept, it could be argued that much research has in fact touched upon ADHD children's emotional functioning in one way or another. Diverse perspectives, such as parent- and self-reported accounts of affective lability and comorbidities, social information processing or temperament can be conceived as questioning the role of emotions in ADHD children's outcomes [3, 11, 68]. However, only a limited number of studies to date have effectively investigated the emotion-centred theory in children with ADHD as a means of understanding underlying mechanisms of their behavioural expressions [69, 70].

In what follows, our focus consequently will be on studies that have explicitly undertaken to test hypotheses about ADHD children's functioning through the lens of emotion regulation. Given our focus, the discussion will more specifically highlight the fields of ADHD children's emotional functioning that have remained relatively neglected to date, namely their physiological reactivity, basic and contextual emotional appraisal skills, along with, to a lesser extent, deliberate emotion regulation efforts.

## 5. Emotion regulation in ADHD children according to the evidence-base

Consistent with the aforementioned facets of emotion regulation (see figure 2), the review of the evidence-base hereafter is organised into arousal, basic appraisal and expression research. Thus, we focus primarily and successively on studies examining how children with ADHD physiologically regulate emotions (§5.1), how they process basic or contextualised emotional cues, mainly in facial expressions (§5.2), and how they deliberately modulate emotional experience and expression (§5.3); this with a priority on recent findings.

### 5.1. Physiological emotional reactivity and regulation in children with ADHD

Children with ADHD's hyperactivity and impulsivity have been posited from an emotion perspective to reflect a basic hyper-arousal tendency, apart from later maturing cognitive control [47]. This tendency has been called emotional impulsiveness, notably by Barkley (2010), and considered to constitute in its own right a core feature of children with ADHD [42, 47, 48]. Emotional impulsiveness is specifically conceived, relative to its cognitive equivalent, as consisting of heightened emotional reactivity along with lessened inhibition of emotional expression [47, 61]. Children with ADHD thus may be expected to show increased physiological reactivity when confronted with affective stimuli compared to non-clinical children. On the other hand, research relative to externalizing disorders, which are often concomitant with ADHD, has suggested that children with anti-social, oppositional-defiant and conduct disordered behaviour present an underaroused autonomic nervous system in general baseline [65, 71] as well as in physical or emotional change conditions [16, 48]. ADHD children's emotional reactivity may therefore also be expected to vary according to the nature of their comorbidities.

On a physiological level, *emotional arousal* reflects in sympathetic nervous system mobilisation, for example through increased heart rate, sweating, muscular tightening and so forth,

which puts the body in basic 'approach/fight' versus 'avoidance/flight' readiness. The *regulation* of emotional arousal additionally involves activation of the parasympathetic nervous system, either unconsciously or through deliberate efforts. Emotional reactivity therefore is often operationalised by confronting children with emotionally evocative material, such as pictures, stories or movies and measuring their changes from baseline in heart rate (HR), blood pressure (BP) or skin conductance (SC) levels [48, 65, 71, 72]. Blood pressure and skin conductance levels hereby provide information about sympathetic activity, whereas heart rate is linked to both sympathetic arousal and parasympathetic physiological inhibition [65, 71, 72]. Furthermore, to obtain a dynamic assessment of effortful emotion regulation, research may present children with emotional challenging tasks while measuring their reciprocal adjustments of sympathetic and parasympathetic responses (see below).

Only a handful of studies to date have directly examined the first component of emotional impulsiveness, namely ADHD children's autonomic nervous system reactivity [48, 65, 71, 73-76]. Most of these studies, moreover, were not emotion-driven, but pertained to physical positional changes [76], cognitively challenging tasks [71, 72] or daily routine conditions [74, 75]. Only one published study appears to have addressed the issue in an explicit emotion regulation context as detailed further on [48].

The findings regarding ADHD children's autonomic reactivity have remained inconclusive so far, depending on comorbidity, selected physiological measures and laboratory paradigms [74-76]. For instance, a naturalistic study of circadian arousal variations revealed heightened diurnal and nocturnal heart rate levels in primary school age children with ADHD compared to non-clinical controls [75]. In contrast, a laboratory study examined whether school-aged children with ADHD had lower autonomic functioning and reactivity relative to those with an anxiety disorder. This was tested during and after a cognitively challenging task requiring mental arithmetic, as indexed by alteration of SC and HR levels [71]. ADHD children's skin conductance did not differ from anxious ones in baseline, stress or recovery conditions. Their heart rate yet showed a decreased response when recovering after the cognitively challenging task. These findings suggest a relative parasympathetic dominance in children with ADHD that was even more pronounced in those without comorbid CD or ODD [71].

Moreover, one early study by Beauchaine et al (2001) used a two-phase paradigm with (indirect) emotional elements, namely a reward and extinction based repetitive response task, that was followed by the viewing of a two minute video portraying escalating conflict between peers [73]. Skin conductance, cardiac pre-ejection periods (PEP) and respiratory sinus arrhythmia (RSA) were investigated as respective indices of sympathetic and parasympathetic responses in adolescents aged 12 to 17 with ADHD (n=17) and ADHD with CD (n=20) compared to non-clinical controls (n=20). Although both ADHD groups displayed lower SC than controls during baseline, no differences emerged during the reward/extinction condition. However, the comorbid ADHD children exhibited more sympathetic reactivity (PEP) compared to the ADHD and control groups at baseline, and relative to the controls only during the reward/extinction phase. They also showed lower baseline parasympathetic activity (RSA) relative to the ADHD-only and control children, but the groups did not differ in

RSA during the video condition. The SC and PEP findings of this study were essentially replicated in a more recent investigation with four to six year old preschoolers at risk for having ADHD and ODD ( $n=18$ ) [77]. Changes in at-risk preschoolers' heart rate in this study further pointed to a predominance of parasympathetic mediation of their autonomic responses in behavioural reward/extinction conditions.

In all, one published study could be identified that explicitly investigated whether children with ADHD display a particular sympathetic and/or parasympathetic reactivity in manifest emotional conditions and whether this differs according to emotions. In a rare laboratory paradigm using active emotion induction and suppression conditions, Musser et al. (2011) indeed examined 66, seven to nine-year old, ADHD and non-clinical control children's autonomic responses [48]. Children were first instructed to facially mimic emotions of a main character viewed in a developmentally appropriate film clip (active emotion induction), and subsequently to imagine the main characters' feelings yet while not expressing any facial emotion (active emotion suppression). The children's sympathetic cardiac PEP and parasympathetic RSA were recorded throughout positive and negative emotion induction and suppression conditions. ADHD and control children's autonomic responses did not differ in baseline or neutral conditions. No significant group differences emerged either in children's sympathetic (PEP) responses. However, ADHD children exhibited a slight yet significant parasympathetic augmentation (RSA), and this inflexibly across all emotional conditions (positive and negative, induction and suppression). Moreover, when expressing deliberate positive facial emotion, the ADHD group responded with a more pronounced ineffective parasympathetic increase in contrast to control children's RSA decrease, suggesting an inadequate emotional approach response.

ADHD children's physiological reactivity has furthermore been investigated along an additional line of questioning concerning alterations in their hypothalamic-pituitary-adrenocortical (HPA) axis. Consistent with the initially outlined expectations, ADHD children have been expected to show blunted cortisol responses to stress [78-80]. Again, studies in this respect have as yet seldom focused specifically on emotional contexts and have yielded mixed results across ADHD heterogeneity. In essence, predicted blunted cortisol responses are evidenced in children with ADHD and comorbid disruptive behaviour disorders. However, children with ADHD and comorbid anxiety disorders tend to show increased cortisol reactivity [78, 79]. Furthermore, one study compared cortisol responses during a public speaking situation among children with ADHD-C ( $n=52$ ), ADHD-I ( $n=23$ ) and non-clinical controls ( $n=25$ ) [80]. In this more manifest psychosocial stress condition, ADHD children's HPA functioning showed subtype distinctions along similar externalising versus internalising lines as above, with ADHD-C children displaying blunted and ADHD-I increased cortisol responses. Finally, one study explicitly examined whether ADHD children's oppositional behaviour would be mediated by their cortisol reactivity to expressed emotions during a family emotion provocation task [58]. High levels of parental negative expressed emotion were indeed associated with both oppositional behaviour and increased cortisol responses in children with ADHD. Cortisol reactivity hereby mediated the emotion-to-behaviour pathway in all children.

*Taken together*, findings remain mixed as regards several aspects of ADHD children's autonomic reactivity. The earlier indications of a heightened sympathetic responsiveness in comorbid ADHD and CD children in a reward-based condition contrast with both underarousal expectations and with ADHD-only children's similar-to-control sympathetic reactivity in an active emotion induction/suppression context. A convergent tendency yet appears to come forward regarding ADHD children's inadaptive parasympathetic responses across different investigation contexts (deliberate emotion induction/suppression versus spontaneous responses to cognitively challenging tasks). This tendency would lend support to behavioural observations that children with ADHD especially have difficulty adequately adjusting their emotional responses [42, 61]. Moreover, ADHD children tend to show altered HPA-functioning, as evidenced in blunted versus intensified cortisol reactivity in respectively externalising (ADHD-C and conduct disorder comorbidity) and internalising (ADHD-I and anxious comorbidity) children. Thus, ADHD children's cortisol reactivity might mediate their emotional responses in emotionally challenging situations. Evidently, however, given the scant number of available studies, further specific examination is required of ADHD children's physiological arousal in emotional conditions. Variations herein according to ADHD comorbidities and subtypes merit further clarification, with the latter remaining largely unaddressed as regards sympathetic and parasympathetic physiological regulation.

## **5.2. ADHD children's processing of basic (facial) emotional cues**

Emotion research in children with ADHD has emerged in part through a select number of 'early' studies examining their facial emotion recognition (FER) skills. Research on FER questions the ability of the child to adequately process or appraise basic emotional cues, a skill that is instrumental to its survival and interactions with others [40, 41, 81]. Although such cues can be verbal as well as non-verbal, especially the latter are recognised to be forceful communication elements and this early-on in development [82]. FER research paradigms thus generally consist of recording children's proficiency in labelling facial emotions, which are either viewed in isolation or within a broader visual or verbal context.

Given the discussion so far, at least four basic questions apply to ADHD children's FER, namely 1) are ADHD children's FER skills compromised compared to those without ADHD?, 2) if so, for which emotions is this the case?, 3) are ADHD children's FER skills linked to their (interpersonal) behavioural functioning?, and 4) which underlying mechanisms may explain ADHD children's FER difficulties?

Altogether, fourteen published studies were identified from 1998 on in Pubmed and through further reviewing of references that have directly addressed (facial) emotion recognition and understanding in children diagnosed with ADHD, besides one study on 'at-risk' children [83] and an ongoing study by our FACE©-ADHD program [30, 84]. As summarised in Table 1 and discussed in paragraph 5.2.1, two-third of these studies [28, 36, 39, 40, 85-89] have focused on simple FER and mostly pointed toward ADHD children experiencing significantly more FER difficulties compared to non-clinical controls. The investigated samples however remain relatively small and diverse in terms of context and comorbidity. Furthermore, precise indications regarding which facial emotions



are more challenging for ADHD children to process remain inconsistent. As reviewed in Table 2 and discussed in paragraph 5.2.2, six studies also focused on emotion understanding in context and/or simultaneously compared ADHD children's simple versus contextualised emotion recognition [39, 41, 81, 90-92].

Authors <sup>1,2</sup> Year Country	ADHD Comparison Age Sex	Type Comorbidity Medication Setting	Measures (primary)	Findings
Ahmadi 2011 Iran	35 A / 31 NC 6-11 Boys	? ? no school	(initial) visual orientation to negative-neutral face pairs	no group differences in initial attention allocation expected orientation tendency to negative emotions in controls
Brotman 2010 USA	18 A / 37 NC 43 BD / 29 SMD 8-17 Boys	? (SA,SP) no clinical	fear, hostility, & nose-width ratings in happy, angry, fearful, & neutral faces; RT amygdala fMRI	Fear: BD & SMD more fear ratings neutral faces: ADHD no difference Hostility, nose-width: no differences ADHD left amygdala hyperactivation vs SMD hypoactivation for fear – nose- width contrasts
Cadesky 2000 USA	68 A / 27 NC 63 ADHD+CP 24 CP 7-13 Boys / Girls	? (ODD) no clinical	DANVA facial & oral happy, angry, sad, fear	Controls; ADHD+CP least errors Fear errors: ADHD+CP 23% vs NC 27% Sadness errors: ADHD+CP 33% vs NC 29% ADHD mostly random errors ADHD; CP more errors, sig for sad, marginal for happy & fear; not for anger ADHD vs CP similar (CP more sad errors)
Guyer 2007 USA	35 A <sup>3</sup> / 92 NC 42 BD / 39 SMD 44 Anx-Dep 7-18 Boys / Girls	? CD yes clinical	DANVA n° errors labelling happy, angry, sad, fear	Most errors by BD and SMD patients All: errors angry > fear > sad > happy Happy: ADHD+CD more errors than controls, less than BD and SMD Angry, sad, fear: ADHD+CD least errors compared to clinical groups and NC
Krauel 2009 Germany	30 A / 25 NC 12-15 Boys	? 16 ODD/CD 40% ?	IAPS, 50% neutral, 25% neg, 25% pos immediate recognition & memory (new / old picture)	All: faster response to positive pictures All: memory negative > positive > neutral ADHD neutral pictures memory < controls (unengaged when no salience) ADHD+CD+ODD memory positive pics lower than controls & ADHDOnly



Authors <sup>1,2</sup> Year Country	ADHD Comparison Age Sex	Type Comorbidity Medication Setting	Measures (primary)	Findings
Pelc 2006 Belgium	30 ? 30 NC 7-12 Boys / Girls	HI no no	Ekman, morphed intensities happy, angry, sad, disgust 7-point rating difficulty (7point)	ADHD general deficit & specific difficulties for anger (high intensity) & sadness (all intensities), not for happiness & disgust poor awareness errors for anger and disgust ADHD FER errors inversely linked to interpersonal problems
Shin 2009 Korea	42 <sup>a</sup> / 95 <sup>b</sup> A 6-10 <sup>a</sup> / 6-15 <sup>b</sup> 27 NC Boys	? no no clinical	<sup>a</sup> ERT: pos / neg; context matching; <sup>b</sup> attention	<sup>a</sup> sample 1, <sup>b</sup> sample 2 No difference in pooled positive (happy, surprise) or negative (angry, sad, fear, disgust) FER between ADHD and controls See table 2
Sinzig 2008 Germany	21 auti+ADHD 19 autism 30 A / 29 NC 6-18 Boys / Girls	I / C CDD/ODD no clinical	FEFA: FER, eye pairs Happy, angry, sad, fear, disgust, surprise, neutral Sustained attention, Inhibition, Set shifting	Autism+ADHD and ADHD poorer facial & eye pair recognition than autism and controls Joy, surprise: ADHD < Autism+ADHD < controls and autism FER linked with sustained attention and inhibition deficits in ADHD children
Williams 2008 Australia	51 A / 51 NC 8-17 Boys	I / C Opp/Anx/Dep no(T1) / yes(T2) clinical	FER Happy, angry, sad, fear, disgust, neutral ERP during 2 <sup>nd</sup> FER naturalistic open design, pre-/post MPH	ADHD(anx/dep) poorer FER anger & fear than controls; no ADHD subtype effects reduced initial occipital activity, followed by exaggeration, & reduced temporal activity during contextual processing After MPH normalized brain activity but no mood changes

<sup>1</sup> First author, see references for full author list | <sup>2</sup> Legend: ? = unspecified, A = ADHD, NC = Non-clinical controls, BD = Bipolar Disorder, SMD = Severe Mood Dysregulation, CP = Conduct problems, CD = Conduct Disorder, ODD = Oppositional Defiant Disorder, Anx = anxiety, Dep = depression, SA = separation anxiety, SP = social phobia, opp = oppositional; I = ADHD Inattentive subtype, C = ADHD Combined subtype, HI = ADHD Hyperactive-Impulsive subtype; MPH = Methylphenidate; RT = reaction times; DANVA = Diagnostic Analysis of Nonverbal Accuracy; ERT = Emotion Recognition Test; JACFEE = Japanese & Caucasian Facial Expressions of Emotion | <sup>3</sup> Sample comprising 18 ADHD, 7 CD, 10 ADHD+CD children

**Table 1.** Published studies on basic FER skills in children with DSM-IV diagnosed ADHD

Authors <sup>1,2</sup> Year Country	Groups Comparison Age Gender	Type Comorbidity Medication Setting	Measures (primary)	Findings
Corbett 2000 USA	37 A / 37 NC 6-12 Boys / Girls	C no no clinical	JACFEE: happy, angry, sad, fear, disgust, surprise, neutral Prosody Test (identify happy, angry, sad, neutral from speech intonation) Inhibition: Go No-Go Task (verbal); Matching Familiar Figures Test (nonverbal) Attention: Memory for Sentences (verbal); Knox Cube Test (nonverbal)	ADHD children significantly less proficient than controls on all measures (visual and verbal emotion recognition, verbal & non-verbal attention, and impulse control with non-verbal stimuli), except for the Go No-Go task where they scored better. FER skills explain 85% of variance in discriminating ADHD from control children.
Braaten 2000 USA	24 A / 19 NC 6-12 Boys	HI C ? no community	Empathy to fictitious story with positive vs negative and simple vs complex feelings (match between labelling characters' emotion and labelling own emotion; explaining characters' emotion) Parent-reported emotional behaviour Self-reported emotional intensity and reactivity to reward / punishment situations	ADHD children less match between characters' and own emotion than controls ADHD less character-centred explanations of characters' emotions than controls More parent-reported emotional behaviour in ADHD children than controls No sign. differences in child-reported emotional intensity and contingency reactivity
Da Fonseca 2008 France	27 A / 27 NC 5-15 Boys / Girls	C 6ODD 1CD no clinical	(1) Magazine pictures (face / body) (2) Similar pictures, masked face (emotional) or object (non-emotional) Happy, angry, sad, fear Non-verbal labelling (Smiley)	ADHD children less efficient in recognising simple and contextualised emotions than controls, no emotion specificity ADHD no significant difficulties in recognising objects in context All: FER happy, angry > fear, sad
Singh 1998 USA	50 - 34 boys 16 girls	? ? no SP <sup>3</sup>	JACFEE: happy, angry, sad, fear, disgust, surprise;	74% mean correct identification for ADHD Errors: Fear>Anger/ Surprise>Disgust>Sad>Happy

Authors <sup>1,2</sup> Year Country	Groups Comparison Age Gender	Type Comorbidity Medication Setting	Measures (primary)	Findings
			to be linked with emotion stories comprising target emotion word	Confusions: fear-surprise, anger-disgust
Shin 2009 Korea	42 <sup>a</sup> / 95 <sup>b</sup> 27 NC 6-10 <sup>a</sup> / 6-15 <sup>b</sup> Boys	? no no clinical	<sup>a</sup> Study 1, ERT: see table 1; Match situational cartoon to facial picture <sup>b</sup> Study 2, Attention: ADS continuous performance target / non-target (omission, commission errors, RT, RT variability)	FER: See table 1 (no differences) ADHD lower contextual understanding (face to situation match) than controls Only omission attentional errors account significantly for ADHD children's contextual understanding (not verified in controls)
Yuill 2007 England	19 <sup>a</sup> / 17 <sup>b</sup> 5-11 <sup>a</sup> / 5-6 <sup>b</sup> Boys	? ?ODD no clinical	<sup>a</sup> Study 1, Match facial expression to emotional situation sentence; match object picture to non-emotional situation sentence <sup>b</sup> Study 2, Same task, with inhibitory scaffolding (impulsive inhibition)	All: non-emotion task easier than emotion task ADHD overall poorer performances; Emotional: 30-40% correct (21% for surprise) vs 79-95% in controls; Non-emotional: mostly 40-50% correct vs 94-100% in controls No age effects; no ODD effects

<sup>1</sup> First author, see references for full author list. | <sup>2</sup> Legend: ? = unspecified, A = ADHD, NC = Non-clinical controls, CD = Conduct Disorder, ODD = Oppositional Defiant Disorder, C = ADHD Combined subtype, HI = ADHD Hyperactive-Impulsive subtype; RT = reaction times; JACFEE = Japanese & Caucasian Facial Expressions of Emotion | <sup>3</sup> Summer program

**Table 2.** Published studies on contextual emotion understanding by DSM-IV ADHD-children

### 5.2.1. ADHD children's simple facial emotion recognition skills

Children generally are able to identify basic facial emotions (happiness, anger, sadness and fear) by early childhood and gain in accuracy to accomplish fuller emotion classification by middle childhood [86]. In children with ADHD, brain imaging studies have documented (posterior) right hemispheric specificities, such as an enlarged right hemisphere structure and hypofused functioning, along with possibly reduced amygdala and compensatory enlarged hippocampus [44, 49]. Since such deficits are profoundly linked to impairments in evaluating emotional stimuli, children with ADHD may be expected to have difficulties in adequately perceiving or processing emotions at an appraisal level [41]. Additionally, ADHD children's fluctuating attentional deployment raises questions as to whether impaired sustained attention also contributes to difficulties in processing affective cues [83].

More precise expectations about differential emotion recognition difficulties have been difficult to formulate. For instance, joy and surprise tend to be more easily recognised by children overall compared to fear, sadness and disgust [86]. Yet, negative facial expressions compared to neutral ones are also documented to mobilise typically developing children's attention; a tendency that is understood as an adaptive response toward potential danger [36, 15]. Children with CD/ODD, which are frequent ADHD comorbidities, for their part seem to display a marked increased bias toward processing negative emotional information in social situations. At the same time, CD/ODD children also appear less aroused by negative emotional stimuli [15, 85]. Thus, detailed expectations about ADHD children's FER skills may depend on their clinical constellation including their comorbidities.

Overall, the reviewed studies point to statistically significant *differences* in basic FER skills between children with ADHD and non-clinical controls or other clinical groups, as illustrated in Table 1 (*question 1*). However, depending on comorbidity and comparison groups, differences are not necessarily to the disadvantage of the ADHD population and/or tend to vary widely as regards which emotions elicit more recognition difficulties (*question 2*). Moreover, whenever performance percentages are specified, a majority of ADHD children (60% and up) still appear to exhibit accurate FER.

Thus, the right hemisphere hypothesis has been supported at least partially as several studies document children with ADHD to be less efficient at identifying *negative facial cues* compared to non-clinical controls [36, 40, 83, 84, 88, 89]. Specific negative FER difficulties, however, vary across studies and children's clinical status, with no clear pattern coming forward. For example, an expected dampened detection of anger and fear was found compared to non-clinical controls in a sample of 51 adolescent boys with ADHD and associated oppositional behaviour along with depressed and anxious mood [89]. This was also the case for anger and sadness, but not for fear, in a sample of hyperactive/impulsive ADHD children without comorbidities [88].

These findings partially converge with pilot results from an ongoing multi-method, multi-informant research that operationalises the above FACE<sup>®</sup>-model. In this research, a naturalistic group of medicated ADHD children in a special school setting is compared with gender- and age-matched non-referred children (ages 7-12, mean age 10, 80% boys) on correlates of emotion regulation [30, 84]. On a micro-level, children are examined on emotional components of ER (basic FER, emotion recognition in context, and self-reported experience) along with cognitive (Theory-Of-Mind), attentional (simple and modified emotional Simon tasks), and behavioural ones (multi-informant reports of problem behaviour including aggression and anxiety). Children's developmental risk-resiliency load is furthermore registered on a macro-level. Compared to controls (n=13), a preliminary sample of ADHD children (n=15) with comorbid learning problems and autism spectrum symptoms (ASS) (respectively 66% and 33%) made significantly more FER errors than controls ( $t(26) = -2,578$ ,  $p = 0,016$ ) and doubted more their choices ( $t(26) = -2,147$ ,  $p = 0,041$ ). These comorbid ADHD children were in particular marginally less efficient at identifying happiness and anger. A second subsample of ADHD children (n=20), also with mainly learning problems but no ASS, did not differ in basic FER compared to controls (n=20) but was less efficient in contex-

tualising emotions, especially anxiety, during a verbal recognition task, as well as in Theory of Mind (also see §5.2.2). For all children, happiness was best recognised facially, followed by anger, and fear (sample 1) or sadness (sample 2) [4, 5, 30, 84].

The aforementioned less expected difficulties with the recognition of the *positive emotion* happiness were also found in children with ADHD and comorbid CD [86], as well as in a comparison among children (ages 6-18) with autism, autism and ADHD, and ADHD-only [28] (see Table 1). In the latter study, both groups with ADHD, namely ADHD-only and comorbid autism and ADHD, were less proficient in recognising happiness as well as surprise on faces and on eye pairs, relative to autism-only and non-clinical children [28].

In contrast, ADHD appears to be associated with *more* successful FER in some instances, as comes forward from a detailed analysis of studies examining whether FER patterns are distinct or cut across clinical conditions. This was the case, for example, in a rare study comparing FER among children and adolescents with BD, severe mood dysregulation (SMD), ADHD and/or CD, anxiety and/or depression and controls [86]. Markedly, the ADHD with CD group appeared to make least errors in angry, sad and fearful FER compared to all other groups, including non-clinical controls. Similarly, another study compared FER among children with ADHD, ADHD with conduct problems (CP) or CP (all with comorbid ODD), and controls. Along with controls, the comorbid ADHD with CP children also exhibited least errors except for sadness, while ADHD-only children mostly displayed random errors.

Findings tend to be clearer regarding the *behavioural and relational impact* of children's FER skills (*question 3*). When this is examined, studies indeed report significant associations between ADHD children's FER skills and daily-life outcomes. For instance, in the pilot study of the FACE©-research, ADHD children's FER skills were inversely proportional to parent and teacher rated ADHD-specific (hyperactivity, inattention, impulsivity) and non-specific (oppositional and aggressive) problem behaviour [30, 84]. Similarly, the above-cited hyperactive/impulsive ADHD children without comorbidities investigated by Pelc et al. (2006) who made more FER errors also exhibited higher interpersonal problems [88].

Finally, some studies attempted to shed light on the neural basis of ADHD children's FER skills (*question 4*) (see table 2). One study examined contrasted amygdala responses when rating emotional cues (fear and hostility) versus non-emotional ones (nose-width) in happy, angry, fearful or neutral faces, and this among youth with BD, SMD, ADHD and non-clinical controls [85]. Interestingly, although ADHD youth did not differ from the other groups in fear, hostility or nose-width ratings, they manifested left-amygdala hyperactivation in fear – nose-width contrasts compared to healthy controls, bipolar and SMD children. Another study, by Williams et al. (2008), recorded ADHD youth's event-related potentials during a second presentation of facial emotion labelling, before and after methylphenidate (MPH) treatment in an open label trial spanning four weeks [89]. ADHD boys showed a pattern of reduced occipital activity during initial perceptual analysis that was associated with their disrupted FER and mood. This was followed by flow-on difficulties in emotion processing, such as an exaggerated structural encoding activity and finally reduced temporal contextual activity. In short, these findings lend further support to possible (compensatory) amygdala responses and specific temporal-occipital pathways in mood processing linked to ADHD.



### 5.2.2. Understanding of emotions in context by children with ADHD

While identifying simple facial emotions represents the most basic form of emotion recognition, real-life communication seldom consists of isolated facial expressions. Facial expressions are mostly if not always situationally embedded. From their earliest interactions, children learn to modulate their appraisal of facial emotions according to the context [66]. As experience develops, this skill increasingly involves (episodic) memory and associated hippocampal functions through which emotional stimuli are linked to (the remembrance of) contextual cues. Specifically, given disruptions in right hemispheric functioning and in the IFC/DLPFC to amygdala circuitry reported for children with ADHD, they may be expected to display difficulties in contextualising emotions over and above their simple FER difficulties [44, 49]. A next level in emotional assessment therefore consists of examining the child's ability to appropriately link facial expressions and (social) situations or to understand emotional cues in their context (e.g. in stories) [42, 64].

All six reviewed published studies (see Table 2) provide evidence that children with ADHD are less successful in reciprocally matching (facial) emotions and interpersonal situations than non-clinical controls (*question 1*) [39, 41, 81, 90-92]. Furthermore, as mentioned above (§5.2.1), the subsample of ADHD children with learning problems of the ongoing FACE®-ADHD research was significantly less efficient than non-clinical controls in identifying emotions in verbally presented stories [84]. Along the same line of thought, an early study by Braaten et al. (2000) stands somewhat apart by addressing a more sophisticated level of emotional understanding. Here, children's ER was further probed by assessing their ability to recognise characters' emotions in a story and to relate these to their own feelings [90]. Children with ADHD were less likely than controls to match their own feelings with those of the child in the story and to interpret the latter according to the characters' context.

Again, however, no clear pattern emerges as to whether ADHD children have more difficulty contextualising specific emotions (*question 2*). For example, an early study with five to 13-year old ADHD boys and girls enrolled in a summer camp, using Ekman's facial affect pictures, suggested a mixed pattern of negative emotions as well as surprise to elicit more contextualisation errors than happiness [81]. Another mixed pattern of better contextualising of happy and angry, than fearful and sad feelings occurred for both ADHD-combined subtype and control children when asked to link symbolic facial expressions (Smiley's) to masked faces of people in popular magazine pictures [91].

Apparently, few of these studies furthermore examined the link between ADHD children's contextualised emotion recognition and their behavioural outcomes (*question 3*). In our ongoing research, children's emotion recognition (and Theory-of-Mind) were found to be inversely related to reports of their externalizing and internalizing problem behaviour in both subsamples regardless of type of ADHD comorbidity [30, 84].

Some studies finally addressed possible underlying mechanisms of ADHD children's difficulties in contextualising emotions (*question 4*). For instance, Da Fonseca et al's (2008) study also included the matching of objects to situational magazine pictures. In contrast to the emotional matching, ADHD children displayed no significant difficulties in replacing ob-

jects in their context, confirming an emotional rather than solely perceptual nature of their matching errors [91]. A study addressing the link between ADHD boys' continuous attentional performance furthermore found only omission errors to account significantly for ADHD children's matching of facial emotional expressions to situational cartoons [39]. Also, in an early yet thorough study involving FER, along with prosody, verbal and nonverbal impulse inhibition and attention tasks, ADHD children's significantly poorer performances on all tasks relative to controls were explained for 85% by their FER skills [41].

Still, findings on ADHD children's contextual emotion recognition seem to remain quite task and/or stimulus dependent. For instance, one study involved the matching of facial expressions to specifically designed emotion-situation sentences, and object pictures to non-emotional sentences [92]. In this case, ADHD boys exhibited exceptionally poor performances with only 20 to 40% of correct emotional and 40 to 50% non-emotional matchings. Control children, in turn, achieved 79 to 100% correct matchings across conditions. These findings contrast with a sensibly higher overall mean of 74% of correct contextual emotion identification by ADHD children documented in Singh's early study [81]. In the same line of stimulus-dependent ER variations, a condition of contextualised emotion recognition in verbal material yielded anger to be least well identified by both control and ADHD children, as opposed to being second-best recognised in a condition of FER [84].

Of note, studies comparing contextual emotion recognition among children with ADHD and *other clinical conditions* or different *subtypes* are still lacking. Simple or contextualised processing of *prosody* also has hardly been investigated in children with ADHD [15, 93]. In adults, emotional semantic processing has been found to be enhanced compared to controls, possibly through compensatory mobilisation of cognitive resources [94]. Similar investigations are needed in children with ADHD.

### 5.2.3. Summary

Overall, ADHD children as a group do appear to display specificities in FER skills that tend to set them apart from non-referred controls and children with other clinical conditions. In addition, the ADHD child and adolescent population also does seem to exhibit more difficulties in matching facial emotions to contextual clues, or recognising emotions in verbal context, compared to non-clinical controls.

The pattern of these basic and contextualised (facial) emotion recognition specificities yet remains unclear to date. ADHD children with or without comorbidities are diversely found to be less efficient in recognising simple negative as well as positive facial emotions compared to non-clinical controls and possibly also to children with different clinical conditions. However, the opposite occurs in some instances, with some large comparison studies documenting better FER skills in (comorbid) ADHD children relative to other clinical and non-clinical groups. Comorbidity or medication statuses do not appear to provide sufficient leads for explaining these contrasting outcomes. Potential influences of maturation (age) and ADHD heterogeneity (subtypes) still require further clarification given that half of the studies span child through adolescent populations, and that the majority leaves ADHD subtypes unspecified. Also needed are studies that address potential gender effects on simple or contextual-

ised emotion recognition with sufficient participation of girls with ADHD. The effects of verbal versus non-verbal stimulus modes as yet remain underexplored too.

Furthermore, when FER difficulties are documented in ADHD children, these appear to be linked to adverse behavioural and interpersonal outcomes. Similar links remain to be further established for ADHD children's contextual emotion recognition.

Finally, there are some indications that ADHD children's basic and contextual emotion recognition skills are related to specificities in right hemispheric emotion-processing and (left) amygdala hyperactivity, while attentional impacts remain less well established. The intricacy of cognitive and emotional systems hereby points to the need of considering multiple pathways of underlying mechanisms instead of mutually exclusive ones, whereby probable compensatory functioning may contribute to explaining the absence of observed emotion processing deficits in some instances.

In sum, the heterogeneity of the population of youth with ADHD, the relative scarcity of current studies directly addressing their emotion recognition skills, and the contrasting outcomes so far all call for a research agenda that would more systematically examine the extent to which gender, age, ADHD subtypes, comorbidities and stimulus type account for variability in ADHD children's basic and contextualised emotion recognition skills.

### **5.3. How do children with ADHD (deliberately) modulate subjective experiences and behavioural expressions of emotional reactivity?**

As defined previously, emotional impulsiveness consists of diminished inhibition of emotional expression besides heightened emotional reactivity (cf. §5.1) [47, 61]. ADHD children's difficulties with modulating their emotional expressions have been mostly documented indirectly through a vast literature attesting to their externalising problem behaviour. Specific examination of the behavioural component of ADHD children's emotional impulsiveness to date has mainly concerned their management of frustration, and this principally in cognitive task-interference contexts [61, 83].

On a behavioural level, children with ADHD are inclined to favour situations that provide immediate reward. They also tend to have difficulty persisting when gratification is delayed. This tendency has been described under the delay-aversion hypothesis [66]. Still, the question arises what makes it more difficult for children with ADHD than for their peers to delay reward and persist when positive reinforcement remains uncertain? From an emotion-centred perspective, ADHD children's difficulties with persisting under delayed reward conditions are thought to be mediated by the challenge of regulating negative emotions, and especially frustration.

Several studies have therefore explicitly investigated how children with ADHD modulate their emotional experience and expression in constrained task conditions that elicit frustration. Frustration is defined here as the emotion resulting from an absence of reward when such reward is expected [82]. Persistence can thus be conceived as the ability to adjust or modulate frustration perception so as to maintain task-oriented behavioural continuity.

Study paradigms consequently generally consist of manipulating children's reward expectancy and registering their self-reported and/or behaviourally observed emotional responses.

Most studies have confirmed children with ADHD to experience heightened frustration levels in association with persistence and behavioural control problems, this both in cognitive task conditions [66, 95, 82] and in less investigated emotional contexts [9]. Detailed accounts of their task-related emotional experiences however provide important nuance regarding ADHD children's emotional understanding and process insight [66, 82].

For instance, an early study compared how seven to nine year old, clinically-referred ADHD children (n=22) and non-referred controls (n=20) compared on performance, study-time, self-rated persistence (namely how much did the child feel like continuing), and facially recorded frustration levels during a nonsense word learning task [82]. Children were assigned to either a predetermined continuous reinforcement (CRF) or partial reinforcement (PRF) condition. The CRF and PRF conditions both consist of an acquisition phase followed by a non-reward extinction phase, yet PRF involves random instead of continuous reward during acquisition. Importantly, reinforcement pertained to persistence rather than task correctness in this study. As expected, learning occurred in both phases for both groups. Children with ADHD yet made more errors, expressed more frustration and felt less like persisting overall. Interestingly, especially the random reward (PRF) condition yielded three-fold frustration levels in ADHD children during the acquisition phase along with a persistence deficit. In turn, only children with ADHD (and not controls) in the CRF condition spent more study-time over the acquisition course [82]. Thus, children with ADHD displayed a marked difficulty habituating to initial frustration, while investing considerable effort in a consistent reward condition.

In the same vein, self-reported frustration was studied in medicated children with ADHD (n=21; mostly combined subtype) compared to non-clinical controls (n=43) using a blindfolded puzzle task [66]. This study moreover recorded detailed accounts of children's emotions, such as their self-reported mood after the task, general persistence and frustration tendency (likeliness of quitting and getting frustrated compared to peers), insight in the accompanying physical, emotional, or cognitive sensations of their frustration and how they dealt with it. Children additionally completed a structured emotional competence self-report measure, along with a mathematics task. Consistent with the previous findings, the present ADHD children were less persistent overall but invested as much time as control children in the tasks. This yielded them mixed results: they were more likely to quit the puzzle task and completed less mathematic problems than their peers, but the ones they completed were accurate. Of special interest for the present focus, the children with ADHD were likelier to report suffering frustration and give up compared to other children, were able to identify signs of their frustration and knew about ways of dealing with it. However, they were significantly less effective at acting upon this emotional understanding than controls.

Children with ADHD have also been demonstrated to have difficulty deliberately masking their emotions in an elicited frustration situation [95]. One study for instance examined ADHD boys' (n=26, ages 6 to 11) observed emotion regulation compared to that of controls (n=23), by explicitly asking them to hide their feelings even if they became upset during a



competitive Stop Signal Task with peers. The boys with ADHD not only had more difficulty with regulating their emotions compared to their non-clinical peers, they were also less successful at hiding their emotions despite knowing that they were expected to do so [95].

Of note, the previous studies examined ADHD children's emotional expression in cognitively challenging contexts. Two other studies did so too in more explicitly emotion-related interpersonal contexts. One study used a prize paradigm with 8 to 11-year-old medicated children with ADHD-combined (ADHD-C,  $n=16$ ) and inattentive (ADHD-I,  $n=14$ ) subtypes (12 boys, 9 girls) compared to controls ( $n=17$ ) [9]. Children's emotional responses were recorded in disappointing versus non-disappointing conditions, namely receiving an unwanted versus a desired prize, after they had been asked to rank prizes in order of desirability and told they would receive prizes for helping another examiner. Emotion-focused measures included children's facial and non-verbal reactions (classified as positive, negative, social monitoring or tension behaviour), along with self-rated affect (how they felt about the prize, how frustrated they felt and how they liked the prize). As expected, all children generally displayed condition-congruent behaviour, along with more intense self-reported affect following disappointment and more interest and effective ER in the non-disappointing condition. Children with ADHD-C additionally showed a trend toward more negatively behaving after disappointment, experiencing more prize interest and affect intensity as well as poorer ER than inattentive and control peers. Remarkably, children with ADHD-C also showed significantly more positive behaviour overall (regardless of condition) than their inattentive and control peers [9]. These findings concord with evidence stemming from physiological reactivity research (cf. §5.1), suggesting that children with ADHD, and among them mainly those with the combined subtype, experience difficulties in adjusting their emotions and related behaviours across shifting situational demands.

A study by Melnick & Hinshaw (2000) employed a more ecologically valid approach by using a videotaped frustrating family task to examine emotional reactivity and regulation among six to twelve year old, low aggressive ( $n=23$ ) and high aggressive ( $n=25$ ) ADHD boys compared to non-clinical controls and their parents (see §5.4 for the latter) [60]. Frustration, or negative emotion, was elicited by asking the child to complete a construction model with parental help while two building pieces were lacking. Children's behaviour was coded as regards the intensity of their emotional ventilation (or reactivity) and the appropriateness of their emotion modulation strategies (such as problem solving, seeking help, accommodating, negative focussing or shutting down). Interestingly, no generalised ER difficulty could be demonstrated for these ADHD children. Observer-rated aggression was also not related to children's emotion regulation strategies overall, nor was emotional reactivity a significant predictor of their behavioural and social (peer) outcomes in this study. However, within-population distinctions emerged whereby high-aggressive ADHD boys exhibited expected overreactive emotions and impaired problem solving, whereas low-aggressive ADHD boys showed either normal range or underresponsive emotional reactions [60].

It should be noted that, similar to (facial) emotion recognition evidence, findings on ADHD children's emotional intensity and behaviour may present measure-dependent variations. For instance, the early empathy study by Braaten et al. (2000) cited in paragraph 5.2.2 addi-



tionally assessed children's emotional behaviours, intensity and reactions to contingencies using reported responses to hypothetical reward and punishment situations instead of live laboratory paradigms [90]. The use of these formats yielded parent-reports of more manifest signs of sadness, anger and guilt in ADHD boys but no self-reported differences in emotional intensity or reactivity compared to controls.

Finally, the chronic and pervasive impact of emotional impulsiveness is documented in a rare longitudinal study that followed up on hyperactive (n=158) and community control (n=81) children, currently 27 years of age [47]. Participants reported on emotional impulsiveness (such as impatient, irascible, easily excited, frustrated, annoyed and emotionally over-reactive behaviour) and were interviewed on multiple domains of functioning (e.g., home life and responsibilities, marital life, social interactions and leisure activities, occupation, and so forth). Emotional impulsiveness was highly correlated with the interrelated dimensions of inattention and hyperactivity-impulsivity in participants with persistent ADHD. The severity of emotional impulsiveness furthermore contributed uniquely to participants' overall impairment and multiple domain-specific adverse outcomes.

*Taken together*, these studies' findings lend credence to the emotion-centred expectations that ADHD children's (cognitive) abilities may become masked, not only by task modalities, but significantly so too by difficulties in modulating their emotional responses across tasks and situational demands. They also indicate that children with ADHD may especially benefit from support in translating mood- and mood-repair-knowledge into action. Still, there is ample room for further investigation of ADHD children's deliberate modulation of emotional responses in emotional contexts. The small number of studies and limited investigation scope leave more open questions than answers for the time being, notably regarding whether and to what extent children with ADHD experience differential emotion regulation difficulties depending on the type of emotions, their intensity, the interaction styles and the involved relational contexts, to name but a few. The longitudinal findings on the unique life-long impact of emotional impulsiveness underline the importance of uncovering early intervention leads for supporting youth with ADHD to behaviourally modulate their emotions.

#### **5.4. ADHD children's emotion regulation in the context of parenting and family risks and resources**

The reviewed evidence-base suggests that children with ADHD differ from other children in their processing of facial affective clues, are less effective at matching (facial) affect and context, experience higher frustration levels in (cognitively) challenging situations and experience more difficulty habituating to negative feelings and/or modulating these by acting upon mood-repair techniques, despite some degree of insight into internal emotion-related signals. Importantly, these difficulties occur even though children with ADHD appear to invest considerable effort into 'doing well' and complying with external instructions.

From a theoretical viewpoint (see paragraph 3.2), these observations raise questions about contextual effects, and especially parenting and family ones, on ADHD children's emotion regulation skills. Several macro-level pathways may indeed influence the development of ER skills in children with ADHD, both directly and indirectly, as illustrated by the arrows in

Figure 1. Exploring these contextual pathways seems all the more pertinent given the observed discrepancies of ER findings within the ADHD youth population and apparently insufficient explanatory value of subtype, comorbidity or medication-statuses.

The most *direct* contextual effects on ADHD children's ER skills concern the way in which parents raise their children and run the family as regards these skills. Mediating and moderating effects of, for instance, parental depression, marital conflict, and critical and harsh parenting indeed already have been documented in general developmental studies and in research regarding predictors of early-onset conduct problems [53, 96, 97]. With the increased recognition of adult persistence of ADHD, many children with ADHD are acknowledged to grow up in families with at least one parent with ADHD [8, 43] and possibly siblings too [55, 96]. Emotional impairments in children with ADHD therefore are expected to be reciprocally shaped by their personal neurobiological predispositions and parenting- and family-related disruptions in emotion regulation [8, 14, 43, 57, 97, 98]. ER disruptions also involve *less direct* effects, such as ADHD children's observational, modelled learning of emotion expression through their parents and possibly siblings. Moreover, structural and functional contextual risks and resources are known to operate through *cumulative and relative principles*, also described as psychological allostatic load [7, 13, 30, 35, 53]. For example, an accumulation of family members with ADHD, internalising or externalising comorbidity, family conflict and an adverse school climate would expectedly culminate in mutually undermining effects on the ADHD child's ER skills. Conversely, the presence, for example, of family members with strong emotion regulation skills and a supportive school climate would constitute cumulative resources that stimulate the ADHD child's emotion regulation skills, or at least counterbalance its personal liabilities to this regard.

Unfortunately, to what extent parental, parenting and family ER difficulties affect specific ER components in ADHD offspring has hardly been empirically examined. A Pubmed search with the key-words 'ADHD', 'emotion regulation' and 'parenting' yields a mere five published articles, among which only the above-cited study of Melnick et al. (2000) directly tackled the subject (see §5.3) [60]. In this previously described videotaped frustrating family task, besides from child ER, parental behaviour was also observed as regards positive versus negative parenting (e.g. situational advice, warmth, structuring and empathy versus negativity, intrusiveness, withdrawal), along with personal (global) emotion regulation (e.g. anxiety, maintenance of focus on and interaction with the child). Mean levels of parenting behaviour did not differ significantly among the ADHD (sub)groups and control children. However, parental anxiety/nervousness and mother's negativity were significantly associated with child global emotion regulation difficulties overall; whereas father's global ER and advice-giving were marginally linked with child positive coping behaviour.

These findings are consonant with several other research reports linking parental negativity, sometimes in association with parental ADHD, to (self-reported) adverse outcomes on emotion regulation in ADHD offspring and this throughout the life span [21, 47, 99].

For instance, in the broader literature children with ADHD have been described to resort to overestimation of their social, behavioural or family-related self-perceptions, probably as a compensation mechanism for excessive emotionally negative interactions [98, 99]. This phe-

nomenon, described as the positive illusory bias, was investigated in one study as regards its link with parental emotional expression among families with seven to ten year old children with ADHD compared to controls (N=56) [99]. Parental criticism was indeed associated with greater positive illusory bias, and parental warmth with lower bias regarding social functioning in children with ADHD. Such findings call for the investigation of comparable parenting effects on ER aspects such as ADHD children's physiological reactivity, basic or contextualised emotion appraisal and behavioural modulation.

Regarding behavioural modulation, a retrospective study for instance examined whether recalled parental ADHD and parenting behaviour related to current emotion regulation among adults with persistent ADHD (n=73, mean age 40, half combined/half inattentive subtypes) [21]. The ADHD adults whose mother possibly had ADHD recalled more maternal rejection and punishment, less paternal rejection and punishment, along with more emotional warmth. These retrospectively identified maternal parenting characteristics, as well as recalled maternal ADHD symptoms, were linked to current insecure emotional functioning and interpersonal relationships. ADHD adults' current attachment and emotion processing patterns were not similarly linked to recalled paternal ADHD and fathering characteristics.

To conclude on potential contextual influences on ADHD children's emotion regulation, it is noteworthy that the cultural component hereof has drawn little attention so far. While basic FER is considered to be relatively universal, this assumption is far less evident for the contextual embedment of emotions and for their behavioural correlates. One study for instance found parenting strategies among children with ADHD to differ by ethnicity, although this did not moderate treatment outcomes [100]. Potential effects of ethnicity and culture on ADHD children's appraisal and expression of emotions thus deserve examination.

*In sum*, the frequent cumulative presence of ADHD among family members by itself forms a considerable risk burden that may increase emotion dysregulation in children with ADHD or constitute critical obstacles toward their learning of effective emotion regulation. While these risks of parental ADHD, negative parenting and family interactions are easily conceived, there is a lack of empirical research that investigates when and how such cumulative risks versus resources specifically operate in the ADHD child's acquisition of emotion regulation skills.

## 5.5. Summary

Behavioural observations, neurobiological and brain imaging data have led to postulate that children with ADHD may experience disrupted emotion regulation. More specifically, ADHD children are expected to exhibit right hemispheric- and attention-related emotion recognition difficulties along with emotional impulsiveness, including heightened physiological reactivity and lessened control of behavioural emotional expression, as synthesised at micro-level of the FACE-model. ADHD children's emotion regulation consequently merits investigation as regards their physiological arousal levels, basic and contextualised appraisal of (facial) emotional cues and modulation of emotional behaviour.

Our review of the current evidence-base concerning ADHD children's emotion regulation reveals a still emerging field that involves a wide scope of ER components and operationalisations, which have only been investigated to a limited extent to date. This state-of-the-art prohibits drawing definite conclusions on the extent to which the ADHD youth population exhibits the expected ER difficulties, and the degree to which these apply to its heterogeneous subgroups as regards subtypes and comorbidities. Further empirical evidence is required too regarding how, precisely, parental, parenting and family dynamics hamper versus foster specific aspects of ADHD children's emotion regulation.

Taken together, the available studies nevertheless suggest that children with ADHD tend to differ from other children in their processing of facial affective clues and are at-risk for being less effective at adequately adapting their physiological arousal to situational demands, and at matching (facial) affect and context. Children with ADHD also appear vulnerable to experiencing higher frustration levels in (cognitively) challenging situations, and having more difficulties with behaviourally habituating to negative feelings and modulating these by acting upon mood-repair techniques. This happens despite indications that children with ADHD do demonstrate some degree of insight into internal emotion-related signals. Perhaps even more importantly, it appears that children with ADHD invest considerable effort into 'doing well' and attempting to control their negative emotions when requested to do so, yet these efforts are seldom acknowledged and/or accompanied by the expected results. The prevention and intervention implications hereof are discussed hereafter.

## 6. From studying to facilitating ADHD children's emotion regulation

Translating research into practice remains an important challenge for designing, implementing and evaluating ADHD prevention and intervention programs [6, 18, 57, 101]. Several characteristics of the extant ER research yet call for caution when attempting to move from the evidence-base toward one-on-one practice with ADHD children. We therefore first analyse conditions for a cautious interpretation of the evidence-base that also foster a strengths-based approach, this along three related lines pertaining to the individual, the proportional and the clinical relevance of the empirical findings (§6.1). Several potential implications of the ER evidence-base for emotion-oriented intervention with ADHD children and their families are considered subsequently (§6.2).

### 6.1. Cautions and conditions for an evidence-based, resiliency-oriented practice

A *first* and fundamental challenge when relying on the evidence-base for practice consists of deciphering its potential relevance for the individual child with ADHD and its family. Empirical research indeed mostly reports on statistically significant differences between groups of children with and without ADHD; or on *group-level* correlations between the ADHD status and several emotion regulation aspects. Such mean differences or group-wise correlations evidently do not concern all investigated ADHD children. Most of the current research data thus critically leave open questions as to which children within the investigated ADHD



groups are more particularly concerned by specific ER difficulties [ 19, 28, 37, 46]. Moreover, cross-sectional research, which is currently dominant, informs little to none about children's personal trajectories, while understanding these trajectories is crucial to guiding prevention and intervention efforts with individual ADHD children and their families.

A *second*, related challenge consists of clarifying the proportions of children with ADHD who are vulnerable to exhibiting ER difficulties. Percentages of ADHD versus control children concerned by the observed ER differences indeed are not systematically provided in many studies. A clear view of the proportion of the investigated ADHD children facing emotion regulation challenges consequently does not automatically emerge from the evidence-base. Closer analysis nevertheless reveals that oftentimes only a minority or a subgroup among the children with ADHD presents deficits in the investigated emotion regulation components, while a majority successfully accomplishes the tasks at hand. Practice relevance would consequently be enhanced if empirical research were oriented to a larger extent on identifying the subsets of ADHD children who account for the differences in emotion regulation observed between investigated groups.

A *third* challenge concerns the clinical relevance of statistical findings. Group-level *statistically* significant differences or correlations do not naturally equal *clinically* significant levels of emotion dysregulation in (all) children with ADHD [6]. When studies report statistical ER differences between groups of controls and children with ADHD, it therefore still remains to be specified to what extent these *differences* correspond to clinically relevant functional *impairments* in the latter. This challenge is compounded by the inherent chiasm between, on the one hand, striving toward as 'pure' as possible research conditions, and on the other hand, obtaining ecologically valid insights of how ADHD children's emotion regulation efforts unfold when cognitive, emotional and behavioural stimulus input and output occur simultaneously in a continuous loop of adjustment processes.

Additionally, and contrasting with a voluminous parenting literature and demand, very little empirical research has been devoted to the potential emotional strengths that may come with ADHD [13]. A growing resiliency-oriented literature yet suggests that the aim of helping ADHD children better deal with their personal and interpersonal challenges may be more difficult to attain when weighing in on 'what goes wrong' without simultaneously trying to understand 'what goes right' [102]. The macro-level of the FACE-model indeed reminds that solely assessing ADHD children's emotion-related problems does not provide a valid view of day-to-day dynamics. Importantly, it creates the risk of overlooking child- and family strengths that contribute to compensating, alleviating or avoiding negative emotional outcomes in the ADHD child's development [31]. This omission of strengths, or of at least a balanced risk-resiliency assessment, may contribute to accounting, for instance, for the proportions of children with diagnosed ADHD in which no significant emotion regulation deficits are found in the discussed studies.

Altogether these factors add to necessary caution when linking empirical data to real-life implications for ADHD children and their families. Given a generalised tendency to overgeneralisation, evidence-based practice would benefit from studies adding more ecologically valid indices in their conclusions regarding the profiles of ADHD children to which ob-



served emotion processing and regulation characteristics apply, and to which degree these correspond to clinically relevant impairments [6, 19]. Even when considering that emotion regulation training probably constitutes a valuable asset to any prevention and intervention effort, the main preoccupation for children with ADHD still consists of tailoring such efforts as closely as possible to their particular ER challenges. The current knowledgebase hereby points to potentially relevant prevention/intervention avenues that merit individual tailoring when addressing ADHD children's emotional functioning in practice.

## **6.2. How to face emotion regulation in children with ADHD and their families: Prevention and intervention keys**

Bearing the discussed cautions in mind, an integrated theory-grounded, evidence-based and strengths-oriented approach offers several instrumental leads for accompanying children and their parents towards facing emotionally disruptive facets of ADHD and equipping them with emotion regulation strengths.

On a *micro-level*, it appears key to help at-risk ADHD children with adjusting their emotional reactivity, with appraising how emotions relate to particular contexts, with recognising negative emotions, and with acquiring problem solving, mood-adjustment knowledge and techniques to act upon this knowledge.

On a *macro-level*, parents with ADHD are likely to find solace in the same focuses, while parents of ADHD children in general may benefit from psychoeducation about the aforementioned ER specificities in their children (and partners) and from tailoring emotion regulation and problem solving techniques to these specificities.

Given the most directly influential impact of parenting on the child's life, it appears particularly important for practice to identify parental ADHD as well as parental emotional resources. Indeed, adults who suffer emotional disruptions themselves confront a significant parenting burden when rearing one or more children with ADHD. Parents with ADHD, but also with other affective issues such as depression, may be particularly vulnerable toward disrupted emotion regulation [43]. Conversely, since not all parents of ADHD children present with ADHD and not all ADHD parents suffer (the same extent of) emotional impairments, recognising ER resources in parents represents a valuable asset for building resiliency in their children. Identifying the ER strategies acquired by parents with ADHD hereby especially offers added value because this simultaneously allows drawing on experience-tested insights, promoting empathy with the ADHD child and engaging in uncovering existing strengths in the family.

An illustration of these principles can be found and is currently evaluated in the ongoing FACE®-ADHD program, which consists of thirteen weekly, 2-hour sessions combining child and parent intervention [4, 5, 30]. Sessions evolve from psychoeducation through problem-solving activities and cognitive-oriented parenting support, toward more specific targeting of (negative) emotions, building emotional skills and training in emotion regulation so as to reduce negative and increase positive experiences and interactions by and among ADHD children and their parents. In a preliminary evaluation, this approach yielded significant

pre- versus posttest improvements in child- and parent-reported experiential and behavioural outcomes after program completion [4, 5, 30]. The FACE© program hereby also involves stimulating the transfer of clinic-based activities through home activities during which parents and children use self-report versions of the FACE'ogram© illustrated in Figure 1 to map perceived stressors and resources. Micro-challenges in daily adjustments are also monitored through the use of a cognitive-emotional diary (FACE©-CEM) [6]. Similar diary methods have been found useful for identifying ADHD families' daily challenges [103].

Despite a growing range of evidence-based interventions for ADHD children and their families, emotion-centred insights yet still remain sparsely applied in this context [104]. To date, many of these interventions also have more broadly concerned children with oppositional behaviour and conduct problems, whereby ADHD symptoms may be involved but not necessarily amount to formal ADHD diagnoses. Most interventions thus still tend to focus primarily on behavioural and/or cognitive modification techniques, even if emotion-related management is more or less implicitly involved in parent-training intervention components [56, 104-106]. A recent meta-analysis of 40 ADHD-oriented parent-intervention studies hereby showed parenting competence to be the only parent-intervention outcome with a large-to-moderate effect from immediate assessment to follow-up, among otherwise generally moderate-to-small outcome effects [104]. Training outcomes seem to follow comparable trajectories for mothers and fathers, consisting of immediate efficacy followed by limited generalisation and waning longer term effects, although it should be noted that fathers typically have been less implicated and thus less investigated [106].

Interestingly, two interventions that do include a more explicit emotion-centred focus, one of which was aimed at ADHD children, are reported to yield firmer long-term outcomes. Thus, one study assessed whether limiting negative emotional control through the training of parental positive behaviour in a family-centred intervention would amend the growth of children's early behaviour problems [107]. An effortful increase in proactive parenting was indeed significantly associated with lower levels of toddlers' general behavioural problems through age two to four. Another study more specifically evaluated the efficacy of the Incredible Years (IY) interventions for children with a primary ADHD diagnosis [108]. The IY interventions involve emotion-focused techniques, besides more traditional child and parent behaviour modification and parenting support, and have been found effective in reducing negative parenting and externalising behaviour among children with ODD and CD in a series of randomized control group studies [96, 108]. An updated program version was used to more precisely examine IY efficacy with four to six-year-old ADHD children (n=49) and their parents who participated in six intervention months. Emotion-focused targets included emotional coaching and teaching of ER strategies, reducing parental depression and anger and increasing family support. Statistically and clinically significant post-treatment effects were found for most outcome variables; including parent-reported and observed parenting, child social, externalising and ADHD-specific behaviours. Significantly, ADHD children's treatment progress was maintained after one year [108].

Finally and for the sake of exhaustiveness, it deserves to be noted that, given space-constraints, the present discussion did not extensively review medication effects on ADHD chil-

dren's emotion regulation. Briefly considered, the additive value of combining medication and psychosocial treatments has been demonstrated especially for children with intense ADHD symptomatology [2, 105, 108]. It is therefore likely that medication may benefit the efficacy of emotion-focused interventions with these children too, albeit because a normalisation of behavioural activity levels is expected to improve learning conditions and family communication [38]. For instance, a study on 43 elementary-school-age children with ADHD documents the positive impact of amphetamine medication on child and family dynamics [59]. Furthermore, Williams' et al.'s study (2008) on youth's event-related potentials before and after MPH treatment [89], evoked in paragraph 5.2.1, specifically showed that improved brain activity after MPH treatment predicted diminution of emotional lability although not of negative mood. Medication has however also been reported to result in blunted, flattened, restricted and dysphoric emotional expression along with passive and even submissive behaviour among children with ADHD [109]. Optimising medication doses may therefore be crucial, as evidenced by one study reporting curvilinear MPH dose effects on ADHD children's visual focusing and variability of facially expressed emotions [38]. Suboptimal medication protocols might in turn interfere with the process of training ADHD children's emotion regulation skills. Investigating the impact of ADHD medication on emotion-centred intervention outcomes and its differential effects according to symptom intensity, comorbidity and medication dosage is therefore recommended.

*Taken together*, an integration of the nascent empirical evidence-base with the outlined conceptual foundations suggests the importance of incorporating techniques for adjusting emotional reactivity, appraisal and behavioural modulation of emotions when intervening with children with ADHD and their parents, whereby relative focuses merit to be tailored to the specificities of the individual family's risk-resiliency balance and challenges. Research-wise there still is a critical need for prospective, follow-up as well as qualitative studies to move towards more fine-grained evidence-based insights into how and under which conditions emotion regulation training with ADHD children and their parents bears fruit.

## 7. Conclusion

Drawing on the FACE®-model, this chapter has examined ADHD children's emotion regulation skills on a cognitive-emotional adjustment and behavioural expression micro-level, along with parenting and family risks and resources herein on a contextual macro-level. Emotion regulation hereby was operationally conceived as the autonomic and effortful modulation of the transient physiological reactions, the basic and contextualised appraisal, the subjective experience and the overt behavioural expressions involved in emotions.

As far as the extant evidence-base allows concluding, children with ADHD appear vulnerable to some extent to difficulties in modulating each of these emotion regulation components, from adaptively accommodating physiological reactivity through adequately appraising emotions in their context to flexibly modulating experience and behavioural expression of emotions. At the least, children with ADHD as a group seem inclined to process

emotions differently compared to peers so that they are in need of extra support in the skill of emotionally adjusting to habitual contextual demands. Throughout the diverse outcomes for this heterogeneous population, it seems that especially children with an externalising pattern of functioning, namely those with the combined ADHD subtype and/or comorbid conduct problems, are most at-risk for demonstrating emotion regulation difficulties at physiological, experiential and behavioural levels. Although as yet scarcely investigated, parental expressed negativity furthermore appears to adversely weigh in on ADHD children's emotion regulation skills at parenting and family-functioning levels.

Given that the research to date predominantly has investigated ADHD children's emotion regulation in cognitive (challenging) situations, findings hereby primarily underscore the importance of considering the impact of ADHD children's emotional functioning on (cognitive) task accomplishments and of acknowledging their non-apparent regulation efforts. These insights call for incorporating mood-management support for children with ADHD in learning conditions. They also call for a paradigm shift so as to value ADHD children's efforts instead of sole outcomes to a much larger extent than is generally the case in academic contexts.

Importantly, the observation that large proportions of investigated children with ADHD do not exhibit the expected emotion regulation difficulties still tends to go unnoticed. This leaves unexploited critical leads for gaining a refined understanding of the impact of ADHD on a child's life and of the resources that may be more or less naturally present in some families to mend its expected adverse effects. Emerging intervention-outcome evidence also points to promising resiliency-building opportunities through the integration of emotion regulation, problem solving, behaviour modification and positive parenting training for those children with ADHD and their parents who confront emotion dysregulation.

The complex field of ADHD children's emotion regulation thus still remains under-explored empirically on several aspects with practical relevance. Children's physiological reactivity, appraisal of emotional cues and modulation of emotional experience and expression hardly have been examined in inherently emotion-driven contexts, such as during parent-child and family interactions. More ecologically valid indices are therefore needed as to which emotion regulation processes underlie ADHD children's observed emotional disruptions in the daily life situations where they matter most in their early years.

In a theory-grounded research utopia, each of the emotion regulation components specified at the micro-level of the FACE©-model would be investigated longitudinally as they develop in children with ADHD while taking into account probable mediating and moderating effects of their macro-level risk and resiliency balance, especially as regards their parenting and family environment. As an added value, ADHD children's emotion regulation trajectories would be compared with those of children with other clinical conditions.

In an evidence-based practice utopia, research would systematically inform about the proportions and specificities of children with ADHD concerned by clinically relevant emotion dysregulation processes. Even more fundamentally, empirical findings would predictively outline the constellation of cognitive-emotional (micro-level) and family environmental



(macro-level) characteristics of those ADHD children who are most at-risk for emotion dysregulation so as to direct prevention or intervention efforts toward these children.

While patiently building the empirical evidence-base and advocating shifts toward sustained research policies that stimulate large-scale longitudinal investigations, remembering the final aim of ADHD emotion research may facilitate moving toward the outlined practice utopia. This aim would expectedly consist of significantly contributing to ameliorating ADHD children's outcomes. A strengths-oriented evidence-base consequently deserves to integrate research that also focuses on gaining an understanding of the conditions under which children with ADHD do manage to regulate their emotions in functional ways. The current chapter allows concluding that combining the search for dysfunctional emotion areas with the discovery of individual and contextual characteristics of children with ADHD who fare best emotionally despite their vulnerabilities, offers the strongest leads for durably building ADHD children's resilience.

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